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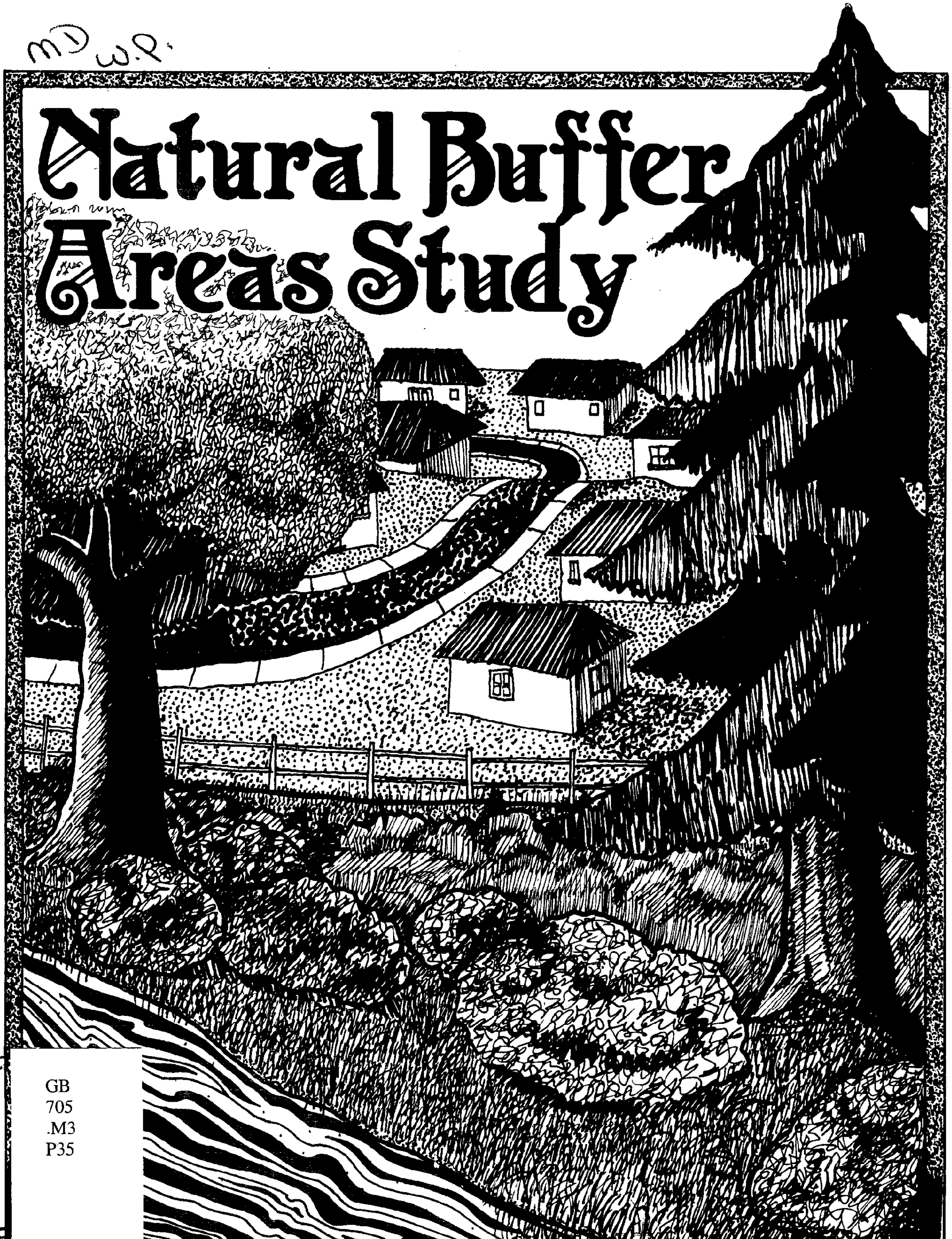
Natural Buffer Areas Study



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Palfrey, Raymond.

THE BUFFER AREA STUDY

by

Raymond Palfrey and Earl Bradley

Coastal Resources Division

Tidewater Administration

Maryland Department of Natural Resources

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INTRODUCTION

Buffer areas are zones of undeveloped vegetated land extending from the banks or high water mark of a watercourse or water body to some point landward. Their purpose is to protect the water resources, including wetlands, they adjoin from the negative impacts of adjacent land uses .

This report reviews these potentially detrimental impacts and notes how buffer areas have been shown to negate or reduce those impacts. Relevant literature documenting these positive functions of buffer areas is cited, and information is presented regarding the environmental factors which determine how effectively buffer areas function. This report concludes with recommendations regarding the establishment of buffer areas in the State of Maryland.

THE USE OF BUFFER AREAS FOR SEDIMENT CONTROL

Introduction

> Falling raindrops, by virtue of their mass and velocity of falling, possess tremendous amounts of kinetic energy. When they strike the earth's surface, this energy can dislodge and mobilize soil particles, initiating erosion."[1]

Once dislodged, the soil particles splashed downhill travel farther than those splashed uphill thus causing a net downhill movement of soil. This process is called "rainsplash erosion." In areas where the rate of rainfall exceeds the soils capacity to absorb it, water accumulates and runs downhill, carrying dislodged soil particles with it in an irregular sheet. The force of this movement of water can dislodge more soil particles. This type of erosion is called "sheetwash erosion." When the soil eroded by both rainsplash and sheetwash erosion is carried to a receiving watercourse or water body, it becomes sediment in the receiving waters.[2]

Recent studies in the Black Creek Watershed in Indiana have shown that while surface runoff accounted for only fifty percent of the total water loss in that agricultural watershed, it accounted for ninety-nine percent of the sediment loss.[3] Thus, it can be concluded that adequate treatment of surface runoff can control sediment inputs into watercourses or water bodies.

Sediment by weight, is the largest single pollutant of water resources in the nation.[4] When it enters water bodies or watercourses, it reduces the productivity of aquatic plant, invertebrate, and vertebrate communities.[5] High concentrations of sediment have detrimental effects on invertebrates such as crayfish and rooted aquatic plants. Very high concentrations-greater than 20,000 parts per million (ppm)-can cause mortality in fish by clogging their gills. While such high concentrations are rarely found in watercourses, lesser amounts threaten the survival of fish by covering essential spawning grounds, smothering their eggs, and preventing the emergence of recently hatched fry. Sedimentation has been cited as one of the major causes of the decline in quality of fisheries throughout the United States.[6]

The significant proportion of invertebrate species which spend the majority of their lives in the bottom substrate are further impacted by sediment because it reduces substrate types.[7] This inevitably leads to the elimination of some invertebrate species and an overall reduction in the total invertebrate population.

In studies in Maryland, silt deposition of 2 millimeters (mm) was found to cause 100% mortality in white perch eggs with sediment thickness of .5-1 mm causing mortalities in excess of 50%. In addition, turbidity in excess of 100 ppm was found to greatly inhibit fish growth and reproduction.[8]

The Effectiveness of Buffer Areas for Sediment Control

Vegetative buffers can reduce both sediment generation and sediment transport. Reduction in sediment is accomplished both by vegetative cover reducing the impact of falling rain and by roots binding soil particles together. It has been noted that a thick cover of vegetation intercepts virtually all the kinetic energy of rainfall thus reducing sediment generation. Thus, grading of development sites should be kept to a minimum. With respect to sediment transport, studies in agricultural and forested watersheds have shown that the maintenance of vegetated buffer areas adjacent to watercourses and water bodies can inhibit the transport of sediment to these water resources. In a 1974 study in the Black Creek

Watershed in Indiana, Mannering and Johnson passed water containing sediment through a 15 meter (49.2 foot) strip of bluegrass sod. In a single trial, they determined that 45% of the sediment was removed from the water.[9] In a similar study in the Black Creek Watershed, tests utilizing a rainulator showed that a 50-foot strip of bluegrass sod removed 46% of the sedimentation in water flowing from a test plot.[10] Stanley Wong and Richard McCuen, in a report produced as part of a study on appropriate stormwater management methods in coastal areas, funded by Maryland's Coastal Zone Management Program, developed a mathematical model to determine the effectiveness of buffer strips for sediment control. In the application of the model to a 47 acre watershed, the use of a 150 foot buffer strip with a 3% slope was found to reduce sediment transport by 90%.[11]

Variables Which Affect the Efficiency of Buffer Areas

The type of vegetation present has been cited as an important factor in determining the effectiveness of buffer areas as sediment filters. In a study of the efficiency of vegetative filters to trap sediment in open channels, cited by James Karr and Issac Schlosser in "The Impact of Near-stream Vegetation and Stream Morphology on Water Quality and Stream Biota," coastal and common bermuda grass were found to be the most efficient species of vegetation for sediment filtration. Their effectiveness for removing sediment is noted in the following table:

TABLE 1

PERCENT REMOVAL OF SEDIMENT AFTER VARYING LENGTHS
OF FILTRATION THROUGH BERMUDA GRASS

	Distance Filtered (Meters)		
Grass Species	90	215	300
Common Bermuda	50.0	90.4	97.0
Coastal Bermuda	55.5	97.5	98.5

It is further noted that grasses used as vegetation filters should have the following characteristics:

1. Deep root system to resist scouring in swift currents

2. Dense, well branched top growth

3. Resistance to flooding

4. Ability to recover growth subsequent to inundation by flooding.[13]

While the efficiency to buffer areas as sediment filters varies with vegetative type, and increases as the width of the vegetated filter increases, this increase is a decreasing exponential function. Stated more simply, the percentage of sediment removed by vegetation increases with the width of the buffer area, but at smaller increments as buffer size is increased.

In addition to width and type of vegetation present in the buffer area, a number of other variables affect the efficiency of buffer areas as sediment filters. The slope of the vegetated buffer area affects the efficiency of the buffer area in a direct manner. As slope increases, the velocity of surface runoff increases, which increases its ability to transport sediment. This means that when buffer areas are established in sloping areas, the width of the buffer must be increased to compensate for slope. Trimble and Schwartz developed the following recommendations as to how wide filter strips (or buffer areas) between logging roads and streams should be in municipal watersheds given sloping conditions. (It should be noted that logging roads were analyzed by Trimble and Schwartz in their study of sedimentation in forested areas because they are a significant generator of sediment in forestry operations).

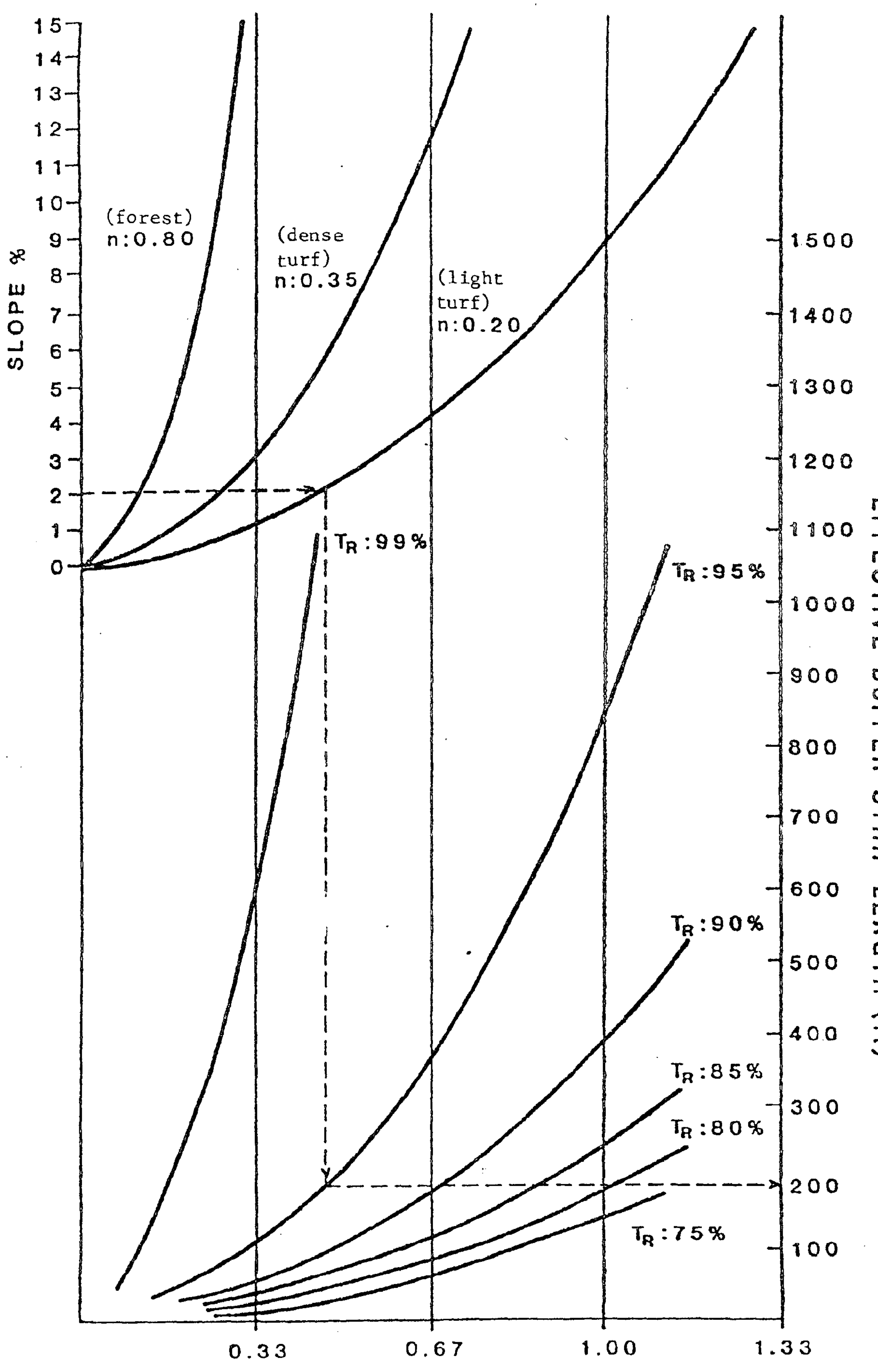
> "Starting with a strip 50 feet wide on level land, the width should increase 4 feet for each 1 percent increase in slope."[14]

While there is a general consensus in the literature that slope affects the efficiency of buffer areas, Rodgers, Syz, and Golden state that slopes greater than 10 percent are too steep to allow any significant detention of runoff and sediment. When such slopes occur next to aquatic resources, according to these authors, they should "be carefully managed, kept covered with vegetation and considered part of the buffer zone."[15]

The height of vegetation in the buffer area also affects its efficiency as a sediment filter. Taller grasses are reported as having higher retardance coefficients than shorter species. Therefore, grasses in buffer areas should not be cut. If they are cut and flow rates are high enough to submerge the grass, their efficiency as a filter declines to zero.

Other factors which affect the efficiency of vegetated buffer areas include: the ability of the soil in the buffer to absorb water, size distribution of incoming sediment, and rate runoff. McCuen and Wong in their report on the Design of Vegetative Buffer Strips for Runoff and Sediment Control have undertaken the most comprehensive analysis of the relationship among these variables in affecting the efficiency of buffer strips.

Figure 1 shows the graphical relationship they developed between trap efficiency (Tr), % slope, runoff velocity, effective buffer strip length, and Manning's roughness coefficient of the vegetation (n).



SLOPE %
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
(forest)
n:0.80
(dense
turf)
n:0.35
(light
turf)
n:0.20
T_R:99%
T_R:95%
T_R:90%
T_R:85%
T_R:80%
T_R:75%
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
EFFECTIVE BUFFER STRIP LENGTH (ft)
0.33
0.67
1.00
1.33
RUNOFF VELOCITY (ft/sec)

Figure 1

THE USE OF BUFFER AREAS TO REDUCE STORMWATER RUNOFF

Introduction

In addition to reducing sediment transport vegetated buffer areas also reduce the total volume of surface runoff. This is because the vegetation in the buffer area retards the flow of surface runoff and allows the soil to absorb much of it. The soil then goes on yielding this water to the watercourse or water body over an extended period of time.

U.S. Department of Agriculture studies in Wisconsin have shown that runoff from grasses is one-fifth of that from continuous row crops.[16] Rotations with grain and hay had intermediate sediment delivery ratios. The reserchers in these studies concluded that runoff is inversely related to the density of vegetation. When runoff volumes from forested watersheds are compared to areas under intense cultivation, the differences are even greater. Runoff from intensely cultivated agricultural land may be as much as forty times that of forested land.[17]

Hewlett and Nutter have shown that in watersheds in a natural condition surface runoff is rare.[18] The natural vegetation in the watershed impedes the flow of runoff and allows it to percolate into the ground. The water is then passed through a soil filter before it reaches a watercourse or water body. Trees, in particular, facilitate this process, since their roots penetrate deep into the ground, aerating the soil and improving its porosity. Their litter and humus also add to the ability of other vegetation to retard runoff. Overall, this process results in a more gradual release of water from the watershed and provides for more stable watercourses and aquatic environments.

On lands which are not covered by vegetation or which are only partially covered, flooding and seasonal shortages of water are more common.

This leads to the conclusion that the establishment of buffer areas adjacent to watercourses and water bodies not only reduces sediment and nutrient transport and moderates water temperatures, but reduces total runoff volumes, the possibility of flooding, and seasonal shortages of water as well.

It should be noted that buffer areas provide additional protection from flooding by providing a margin of safety between watercourses and water bodies and development. Natural processes and changes caused by man often alter hydrology by increasing peak flows. These peak flows can in turn change stream geometry. If such changes become radical, flooding and erosion hazards may result. Buffer areas provide safety from these hazards by providing space between watercourses or water bodies and development.

The Effectiveness of Vegetative Buffers for Reducing Stormwater Runoff

In their paper on "The Design of Vegetative Buffer Strips for Runoff and Sediment Control," Wong and McCuen note that:

> "Buffer strips have not received the attention they deserve as a means of controlling stormwater runoff because they have not been viewed as a viable alternative to the detention basin. Design methods have not been previously developed that can account for the effects of buffer strips on runoff volumes and sediment loadings. However, it seems reasonable that the total volume of detention storage that is required to mitigate the effects of development could be reduced if properly designed and located buffer strips were used to reduce runoff volumes and sediment loadings into the detention facility."[19]

They further note that the reduction in the runoff volume occurs as the vegetation impedes and retards the flow of water, allowing a portion of it to infiltrate the soil. The rate of infiltration is a function of: 1) the condition of the vegetative cover, 2) the properties of the underlying soil, 3) the rainfall intensity, and 4) antecedent soil conditions. These factors act in an interrelated manner to influence the amount of water that infiltrates a buffer strip.

In their analysis of a 47 acre watershed in Maryland, they noted that the location of a 150 ft. buffer strip above the inlet to a detention structure would result in a reduction of runoff volumes of 10 observed Storms of 28%. The reduction of runoff into the detention basin is greatest for the smallest storm event and, in general, the total volume loss will increase when the duration of the runoff is longer.[20]

THE USE OF BUFFER AREAS AS NUTRIENT FILTERS

Introduction

One of the major causes of excess nutrient enrichment, or eutrophication, is the transport of phosphorus and nitrogen from fertilized agricultural lands to watercourses or water bodies by surface and substance runoff. Nutrients, in the right proportions, are not harmful to water resources. In fact, they are essential to the normal life processes of aquatic plants and animals. Under normal conditions, they are supplied by decaying organic matter in or near watercourse or water bodies and provide for a highly productive aquatic environment. Water quality problems only arise when too many nutrients are introduced into the aquatic environment.

Excess nutrient enrichment causes the acceleration of plant growth, partially phytoplankton and algae. This leads to large algal plankton blooms which cause water quality problems including noxious odors and toxic metabolic byproducts. This over-production can also block the light required by desirable aquatic plants for normal growth. While phytoplankton and algae normally produce oxygen, under conditions of accelerated growth they consume . ore oxygen than they produce. This situation can cause a shortage of dissolved oxygen. Aggravating this situation is the fact that these plants have extremely short life spans. This causes a further depletion of dissolved oxygen, since large amounts of dissolved oxygen are used during the decomposition of the dead plants. Maintenance of a moderately high dissolved oxygen content is necessary for the maintenance of healthy aquatic systems.

The Effectiveness of Buffer Areas as Nutrient Filters for Surface Runoff

In studies in the Black Creek watershed, 88 percent of all nitrogen and 96 percent of all phosphorous reaching watercourses or water bodies as surface runoff in agricultural watersheds was found to be attached to sediment particles.[21] As previously noted, data from field and laboratory studies indicate that vegetation effectively removes sediment from surface flows. Hence, the removal of nutrients attached to sediment particles can be accomplished by the filtering of surface runoff through vegetated buffer areas.

In the same study, when fertilizers were applied to agricultural land, slightly higher proportions of phosphorous and nitrogen were found in solution in surface runoff and less attached to sediment. Under this condition, an average of 92 percent of phosphorous and 72 percent of nitrogen was attached to particles.[22] Past efforts to use vegetation to remove the smaller percentage of nutrients which are carried in solution in surface runoff have yielded conflicting results. Reductions of nitrogen and phosphorous as high as 80 percent respectively have been reported using a 90 meter sod filter strip with a slope of 12 percent.[23] Lows of 4 percent nitrogen reduction and 6 percent phosphorous reduction have been reported in an experiment using a 300 meter vegetated filter strip to remove nutrients from municipal effluent.[24] James Karr and Issac Schlosser in "Impact of Nearstream Vegetation and Stream Morphology on Water Quality and Stream Biota" conclude that the reasons for these extreme variations in nutrients removal are difficult to determine due to poorly controlled or unreported experimental conditions. However, four factors were identified as likely to be important to the success in removing nutrients in solution from surface runoff: detention time (related to slope of filter), type of vegetation, volume of water treated, and soil type.[25]

The literature therefore supports the conclusion that the maintenance of vegetated buffer areas adjacent to watercourses or water bodies can significantly improve water quality by filtering nutrients from surface runoff, although the degree of improvement is difficult to quantify.

The Effectiveness of Buffer Areas as Nutirent Filters for Subsurface Runoff

Most of the research undertaken on nutrient enhancement has concentrated on surface flows rather than on subsurface flows. Studies on watersheds in the Rhode River area in Anne Arundel County indicate that nutrients in subsurface runoff may contribute to nutrient enrichment, and that forested buffer areas may sificantly reduce the amount of nutrients in subsurface flows.[26] Research has also been undertaken on effluent runoff from septic tanks. Factors such as soil permeability, groundwater level, stratigraphy, distribution of soil types, and slopes were found to be particularly important to safe use of septic tanks. If there is an inadequate distance between the septic tank and water body, contamination of the water may occur, with nitrates which are particularly mobile in groundwater likely to be the cause of most estuarine entrophication. As noted in Coastal Ecosystem Management by John Clark, the setback presently required for septic systems, typically 50 feet, which may be adequate to remove pathogens is not adequate for the removal of certain dissolved pollutants, particularly nitrates. In many urbanized areas, estuarine bodies have become eutrophic and degraded from septic tank leachates and overflow. Clark cites studies that have shown high concentrations of nitrates at distances of 100 feet from septic systems with unacceptable levels remaining at 150 feet. He therefore recommends that a 300 ft. setback be used whenever possible, with 150 feet the minimum setback considered to be adequate to avoid nitrate pollution.[27]

THE USE OF BUFFER AREAS TO MODERATE STREAM WATER TEMPERATURES

Introduction

Temperature is very important in determining water quality as the table below indicates. As a water temperature increases, the capacity of water to hold oxygen decreases.[28]

RELATIONSHIP BETWEEN TEMPERATURE AND MAXIMUM DISSOLVED OXYGEN CONCENTRATION IN WATER

Temperature	Maximum Oxygen Concentration (ppm)
0	14.6
10	11.3
20	10.7
30	7.6

Since oxygen is utilized in the decomposition of organic matter, elevated water temperatures reduce the ability of streams to assimilate organic wastes without oxygen depletion.[29]

Even more important to water quality is the effect of temperature on the release of nutrients attached to sediment particles. As water temperature increases, the rate at which nutrients attached to sediment particles are released and thus become soluable increases.[30] These nutrients are then in a more readily available form. Data from Sommers, Nelson, and Kamisky indicates that an exponential increase in phosphorous release occurs with increases in temperature.[31] Slight increases in temperature above 15°C were shown to produce substantial increases in the amount of phosphorous released.

The previously cited information indicates that the removal of the vegetation which shades streams will cause several detrimental effects. During the summer months, average temperatures will be higher which will reduce the ability of streams to hold oxygen and cause the release of more nutrients from the sediment particles to which they are attached.

Increasingly large blooms of nuisance algae will result because of elevated nutrient concentrations, temperatures, and light availability. The net effect of these changes will be decreases in water quality and the quality of biotic communities.

Changes in temperature can also cause shifts in the aquatic community. Temperature increases of 6-9°C can make it energetically impossible for some species to continue living in the aquatic environment. In fact, an overall shift can occur in the aquatic community because of temperature increases, with more desirable species replaced by less desirable species more tolerant of increased temperatures.[32]

Headwater streams, which are very important as the breeding grounds for many valuable species of sport and commercial fish, are particularly vunerable to increases in temperature when nearstream vegetation is removed. The maintenance of continuous vegetated buffer areas adjacent to these streams is very important to their biological productivity.

The Effectiveness of Buffer Areas in Moderating Stream Temperatures

A number of studies have shown that the maintenance of nearstream vegetation moderates stream temperatures. The results of some of these studies are summarized below.

G.F. Green compared the temperatures of a stream flowing through farmland to a stream flowing through a hardwood forest over a one year period. The maximum weekly temperature of the farm stream, which was not bordered by vegetation, ranged from 5° to 12.8°C above the maximum weekly temperatures of the forest stream during the warmer months. During the coldest months, the temperature of the forest stream was frequently as high as 3.9°C above the farm stream.[33] Similar effects were recorded in a study of a single stream, before and after vegetation was removed.[22]

These studies indicated that nearstream vegetation protects streams from temperature extremes in both summer and winter.

In a more detailed study of stream temperatures conducted in the Appalachian Mountains by L. W. Swift and J. E. Messer, it was shown that temperature minimums during the warmest months also increased for streams not bordered by vegetation.[35] This indicates that the temperatures of these streams did not decrease significantly during the night. Such prolonged periods of elevated temperatures can have significant impacts on the energy budget of the aquatic ecosystem, causing major alterations in the biotic community. Swift and Messer also showed that if nearstream vegetation was left to shade a stream, while the remainder of the forest was cleared out, only minor changes in stream temperatures would occur.[36] These findings support the conclusion that if vegetated buffer areas are maintained adjacent to streams, significant decreases in stream temperatures will result.

A more recent analysis of the use of buffer areas by G.W. Brown and J.R. Brazier supports the above conclusion.[35] After examining various streams and types of buffers, they concluded that angular canopy density (a measure of the ability of vegetation to provide shading) is the only buffer area parameter strongly correlated with temperture control. Buffer area width was found to be related to the effectiveness of the buffer area to moderate stream temperatures through a complex interrelationship of canopy density, canopy height, stream width and stream discharge.

The study recommended that the angular canopy density be kept at least at 80% coverage. It further concluded that for the average buffer strip composed largely of trees, the maximum angular canopy density and hence the maximum shading ability is reached within a width of 80 feet, with 90% of the maximum reached within 55 feet.

The study also showed that the effectiveness of buffer areas on temperature control increased as stream size decreased. This is generally beneficial in terms of water quality, since small streams tend to have the greatest temperature control problems. The study also showed that if temperatures are controlled in the upper reaches of drainage basins, temperature problems in downstream areas, including reservoirs, will be controlled as well.

THE VALUE OF BUFFER AREAS AS FOOD SOURCES

The input of leaves and twigs from nearstream vegetation is a very important food source for aquatic organisms, particularly in headwater streams.[36] In these watercourses, the microflora which cover leaves and twigs provide the majority of the energy utilized by invertebrates. These invertebrates are at the base of the aquatic food chain headed by predator fish. If nearstream vegetation is removed and vegetated buffer areas are not preserved along the banks of watercourses, the energy budget and, hence, the aquatic structure, will be negatively impacted.

THE VALUE OF BUFFER AREAS AS TRANSITION ZONES

The edge of wetlands includes a transitional zone between the wetland and adjacent uplands which should be preserved to maintain the health of the wetlands. This zone exhibits great variety in soils, terrain, and hydrology resulting in a tremendous variety of plant species. This array of plant species provides food and cover for large numbers of wildlife species. The zone serves many functions crucial to wildlife. It provides food, cover, travel routes, roosting sites, nesting sites, and denning sites. It is crucial to the ecology of the wetlands.

Cultivation, grazing, construction and other impacts within the wetland edge lead to increased surface runoff and erosion into the wetland. This results in siltation which chokes out wetland plants and reduces the size of the wetland. The surface runoff can increase nutrient loading by carrying fertilizers, domestic animal and human wastes, detergents and dead vegetation into the wetland. It can also carry toxic substances such as road salts, petroleum wastes, herbicides, pesticides and industrial wastes into the wetlands. These pollutants reduce water quality and negatively impact the aquatic plants and animals of the wetlands. This in turn affects the wildlife dependent on these organisms as food sources. Thus, while the immediate effect of disturbances in the wetland edge is felt by wildlife directly dependent on that zone, in time the effect will be felt throughout the wetland.[39]

ESTABLISHING BUFFER AREAS

Methods That Have Been Used in Establishing Buffers

The preceding information has documented the ways that vegetated buffer areas can provide protection for sensitive water resources. This section will outline three distinct methods of establishing vegetated buffer areas, will present examples of these three strategies as implemented in various parts of the country, and will present recommendations for the implementation of buffer areas in the coastal zone of the State of Maryland.

The simplest method of establishing a buffer area is to define the area as extending from the banks or high water mark of a watercourse or water body to some point landward. This approach has the advantage of being easy to delineate and administer. Natural vegetation is preserved in this area and any type of development or other land alteration is prohibited within this area.

Fixed point boundaries from as little as 25 feet to as much as 300 feet have been established throughout the country with the buffer width depending as much on political acceptability as scientific justification.[40]

In Maryland, Cecil County has established a special waterfront district consisting of all land within any commercial or industrial zone adjoining tidal waters or wetlands and any land zoned otherwise within 110 feet of the mean high water line or tidal wetland. No buildings, structures and parking areas are allowed within the zone except (1) boat houses, piers, docks, launching ramps, and mooring facilities; (2) marinas and accessory uses in commercial zones; (3) beaches, bath houses and related structures; and (4) industrial uses in areas appropriately zoned provided no industrial structures be located within 500 feet of the mean high waterline unless such structures are required for the operation of the industrial establishment. For such permitted uses, no on-site disposal of sewage or other waste is allowed within one hundred (100) feet of the mean high waterline. Restaurants, motels, and retail establishments serving the boating public are allowed as no special exceptions. Within the district land surfaces and vegetation are to be preserved with vegetative removal or land alteration required to be in accordance with approved erosion and sediment control procedures or as part of crop tillage which is in accordance with an approved soil conservation plan.

In addition, Harford County has established a Natural Resources Protection District consisting of:

(1) areas exceeding 40,000 sq. ft. with a slope in excess of 25%;

(2) tidal and non-tidal wetlands greater than 40,000 sq. ft;

(3) buffer areas around third order streams consisting of 150 feet on both sides of the center line of the stream or 50 feet beyond the floodplain, whichever is greater, and along their tributaries for a minimum distance of 300 feet from the main branch with a minimum distance of 50 feet on both sides of the center line of the tributary or 25 feet beyond the floodplain, whichever is greater; and

(4) a buffer area of 500 feet from the waters edge of the Chesapeake Bay, Back River, Susquehanna River and the Gunpowder River.

Within this district, activities are restricted to protect water quality, minimize erosion/siltation and protect essential vegetation, protect shorelines, wetlands and beaches, protect steep terrain, protect person and property from environmental hazards, and, in general, ensure that use of land within the District protects the ecology of the area. In particular, a 75 foot buffer is to be maintained adjacent to tidal and non-tidal wetlands. Also, clearing of wooded areas is not to exceed 30% of the wooded area with a minimum buffer area maintained adjacent to streams of three times the height of canopy or 50 feet plus four feet for each 1% increase in slope, whichever is greater.

Sensitive environmental areas, including special natural features, significant wildlife habitats, cultivated soils, erosive soils and designated scenic areas are not to be disturbed during any development. In agricultural areas, a vegetative buffer of 25 feet is to be maintained adjacent to stream banks to reduce run-off of sediment, fertilizer and manure. Finally, shoreline areas adjacent to tidal waters are to be minimally disturbed with a maximum of 30% impervious surfaces for a distance of 100 feet landward from the water's edge with at least 50% of any shoreline area maintained in permanent open space.

The main weakness of this method of establishing a buffer area is that it does not make any provision for incorporating adjacent sensitive areas, such as hillsides, poorly drained soils, or areas with high water tables into the buffer area. It also does not take into account any special problems which are t be used in developments adjacent to tidal waters. For example, an increased buffer width may be needed to avoid nitrate contamination.

A second method of establishing a buffer area would be to define the area according to the character of adjacent lands. These lands would be examined and such features as slope, vegetative cover, soil type and porosity would be noted and taken into consideration in the development of the required buffer area width. In areas where sensitive lands, such as hillsides or poorly drained soils are in proximity to the water resource, the buffer area would be extended to include the sensitivity to critical areas along the stream. It is generally referred to as a floating buffer area.

Placer County, California defines its buffer areas (stream environment zones) in this way:

> A land strip on each side of the stream bed necessary to maintain existing water quality. The width of the stream environment zone shall be determined by investigation. Investigation shall consist of:
>
> 1. soil types and how surface water filters into the ground;
>
> 2. types and amount of vegetative cover and how it stabilizes the soil;
>
> 3. slope of the land within the zone and how significant it is for retaining sediment from reaching the streams.[41]

Fairfax County, Virginia has established environmental quality corridors to protect its stream and adjacent lands which consist of:

1. all lands presently mapped as 100 year floodplains or subsequently mapped as such;

2. all floodplain soils and soils adjacent to streams which exhibit a high water table, poor bearing strength, or other severe development constraints;

3. tidal wetlan .s;

4. fresh water wetlands adjacent to streams;

5. steep slopes (greater than 15 percent) adjacent to the above floodplains, soils and wetlands; and

6. at a minimum, where the above floodplain, soils and wetlands cover only a narrow area, a buffer on each side of the stream calculated as follows: buffer width = 50 + (4 x percent slope) in feet.

The potential weakness of this approach lies in the evaluation of the buffer area. If the evaluation is inadequate, the buffer area provided may also be inadequate. An additional drawback of this approach is that it may initially require large amounts of staff time to study the areas adjacent to watercourses and water bodies to determine the requirements for buffer areas.

A third approach, consisting of a combination of the above two approaches, may well prove to be best. Under such a combination, a minimum boundary would be specified, then adjusted depending on the location of adjacent resource areas. If a proposed development abuts the fixed boundary, the regulations defining the buffer area would require the submission of environmental information regarding any resources within the parcel. If areas of environmental significance or areas unsuitable for development are present in the adjacent parcel, the boundary of the buffer area would be extended to include these resources. If no such areas are present in the adjacent parcel, the boundary would remain fixed.

The California Coastal Commission has utilized this approach in establishing its Statewide Interpretive Guidelines for Wetlands and Other Wet Environmentally Sensitive Habitat Areas for its own use and that of local coastal commissions. It requires a minimum buffer width of 100 feet with additional area included in the buffer area upon the following criteria: biological significance of adjacent lands, sensitivity of wildlife species occurring in the buffer area, susceptability of the area to erosion, use of natural topographical features to locate development, use of existing cultural features to locate buffer zones, lot configurations, location of existing development, and type and scale of development proposed.

In a variation of this approach, the New Jersey Department of Environmental Protection has a New Jersey Coastal Resource and Development Wetlands Buffer Policy (NJ Annotated Code, Section 7:1E-3.27) which states that:

"All land within 300 feet of Wetlands as defined in NJ AC 7:7E-3.26 and within the drainage of those Wetlands comprise an area within which the need for a Wetlands Buffer shall be determined."

The precise geographic extent of the actual Wetlands Buffer required is determined on a case-by-case basis to ensure any proposed development "will not have a significant adverse impact and will cause minimum feasible adverse impact, through the use of mitigation, where appropriate, (1) on the Wetlands, and (2) on the natural ecotone between the Wetlands and the surrounding upland."

Recommendations for Establishing Buffer Areas

Based upon the results of the scientific studies noted above and the experience with the use of buffers in Maryland and elsewhere, it is recommended that a minimum buffer width of 100 feet be maintained from the mean high-water line of waterbodies or the edge of tidal and non-tidal wetlands. In addition, buffer areas should be sufficiently wide to include the 100-year riverine floodplain, tidal wetlands, non-tidal wetlands, steep slopes (greater than 15%) adjacent to streams or the 100-year floodplain; soils with severe development constraints (erodible soils, soils with a high water table, soils with poor bearing strength, etc.) adjacent to waterbodies or wetlands; and upland areas adjacent to waterbodies and wetlands which are of high biological significance. In the case of areas which have a slope of greater than 5 % adjacent to wetlands or waterbodies, the buffer area should contain an area of at least 25 feet from the top of the slope. Septic systems should be required to be a minimum of 150 feet from waterbodies. In the case of adjacent land areas of high nutrient loadings, a buffer width of 300 feet should be required in order to ensure the preservation of water quality.

In the case of agricultural uses, no-till farming appears to greatly reduce the sediment and nutrient runoff from agricultural lands and thus buffer areas of lesser width may be appropriate. Also, the implementation of effective soil conservation plans may reduce the width of the buffer areas needed to protect water quality and aquatic resources.

Finally, buffer strips should be considered as valuable components of a sediment control and stormwater management approach, but, in most cases, they are not sufficient to minimize adverse effects from runoff by themselves. Their use, however, can reduce the cost and extent of sediment control and stormwater management measures that otherwise would be required and can retain sediment, nutrients, and non-point pollutants not caught by other measures from entering water bodies and other environmentally sensitive areas.

FOOTNOTES

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